Baseline Survey of Quaking Aspen (*Populus tremuloides*) in City of Rocks National Reserve

June 27-29, 2005

The 2005 OMSI Botany Research Team

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Executive Summary

From June 27-29, 2005, the OMSI Botany Research Team conducted a survey of the quaking aspen population at City of Rocks National Reserve (CIRO). The goal of this survey was to collect baseline data on City of Rocks' quaking aspen population distribution and structure and on the impacts of invasive trees in aspen stands in the reserve. Objectives also included an analysis of results in order to provide pilot data for use in development of a sampling design for long-term monitoring of the reserve's aspen population. Quaking aspen are declining throughout the western United States due to fire suppression, succession to shade tolerant conifers, grazing pressure, and possibly climate change. This decline has significant implications for western ecosystems, including the loss of aspen-dependent biodiversity (Lawler and Edwards 2002, Griffis-Kyle and Beier 2003, Parsons et al. 2003).

Fire suppression and historic over-grazing of fine fuels in steppe vegetation surrounding aspen stands has led to reduced fire frequency in many aspen stands in the intermountain west. This typically leads to succession of shade tolerant conifers in aspen stands, which in turn suppresses aspen reproduction and, eventually, causes the loss of entire aspen stands or clones. Fire also directly encourages suckering in aspen stands, so there is a feedback loop in these systems, where the loss of fire leads to the loss of aspen regeneration. Both native ungulates and domestic livestock can adversely impact aspen regeneration through the consumption of suckers and new leader shoots on aspen trees. This relationship has been dramatically demonstrated in Yellowstone National Park, where excessive browsing by elk has caused a significant decline in the aspen population (Rogers 2002, Larson and Ripple 2003).

In CIRO, quaking aspen grows in stands at varying elevations along wet or mesic micro sites. These are typically in swales or seeps and along riparian areas. Aspen provides an extremely important habitat for invertebrates and vertebrates, including nesting and roosting habitat for birds and bats (Parsons et al. 2003, Griffis-Kyle and Beier 2003). Many species utilize aspen for foraging as well, and the aspen communities in CIRO, while small in size, are disproportionately important to the reserve's biological diversity. To date, no condition assessment of aspen at CIRO has been made. We adapted methods proposed for use in Wyoming and recently presented at the 2002 Conference on Fire, Fuel Treatments and Restoration in Ft. Collins, Colorado to sample aspen stands using 78 m^2 (5 m radii) circular plots along transects with 12 m plot intervals. We sampled in 8 stands, and the number of plots per stand ranged from 5 to 10, depending on stand size. Regeneration in sampled stands was high, with suckers less than 2 m tall dominating stands. Browse impacts were minimal, as was non-aspen tree invasion. Utah juniper and chokecherry competition may be significant in some stands. These data suggest that an additional 15-20 stands would need to be included in the sample population in order to achieve reliable estimates of structural change between years at the 90% confidence level and with a minimum detectable change of 20%. However, additional pilot data are still needed to test assumptions made for this determination.

Introduction

The 2005 Oregon Museum of Science and Industry (OMSI) Botany Research Team conducted baseline sampling of the quaking aspen (*Populus tremuloides*) population in City of Rocks National Reserve on June 27, 28, and 29. The effort was the result of a partnership between OMSI, the National Park Service Upper Columbia Basin Network Inventory and Monitoring Program (UCBN), and the City of Rocks National Reserve (CIRO) to provide an opportunity for high school science students to participate in a "hands-on" field ecology project. The group also traveled to Craters of the Moon National Monument and Preserve to assist with ground-truthing for vegetation mapping and those data have also been provided to UCBN staff. During the last 2 years, OMSI and the UCBN have organized several "citizen science" programs and all have successfully demonstrated that well-trained students, operating under clearly defined protocols, can make an important contribution to the UCBN long-term ecological monitoring program and simultaneously receive exceptional field-based science education. This "tent-and-van" based high school research team program was organized in the same manner as the 2004 Bat Research Team that conducted bat inventory and pilot monitoring activities in three other UCBN parks. The tent-and-van approach has worked well in the UCBN and serves as an ideal model for a network-wide citizen-science monitoring program for NPS networks that consist of widely distributed parks in remote areas.

The primary objective of the aspen portion of the botany team's program was to collect baseline data on aspen stand distribution in the reserve and on the structural condition of these stands. To date, no assessment has been made on the CIRO aspen population but concerns about regional aspen community dynamics has prompted the UCBN and CIRO to identify aspen as an important ecosystem "vital sign" and one to be included in its long-term monitoring program. In order to do this successfully, however, pilot data are critical to the formation of good objectives and sampling design. The data collected by the team were intended for use in important decision making, including sampling methodology and plot size determination, sample size requirements, and other design issues. These data will also assist CIRO managers and UCBN staff to better articulate management and monitoring objectives, including thresholds for management action.

There is widespread consensus that quaking aspen populations are declining throughout the western United States (Peet 2000). Fire suppression has been identified as the most widespread proximal factor, but elk and deer browsing and domestic cattle grazing has also been recognized (Rogers 2002, Larsen and Ripple 2003). Figure 1 is a conceptual model developed by the UCBN to illustrate the relationships between reduced fire, browsing, and grazing on declining rates of regeneration in aspen stands. However, in the absence of data from UCBN parks, these relationships remain hypothetical and the model will require revision as park-specific data become available. While aspen represents only a small precentage of total land cover in the reserve, the type is disproportionately important to it's biological diversity. This has been demonstrated by recent vertebrate inventories as well as published studies from elsewhere in the region (Shive and Peterson 2001, Lawler and Edwards 2002, Madison et al. 2003, Griffis-Kyle and Beier 2003, Parsons et al. 2003). Aspen stands typically establish on more mesic sites with higher productivity than surrounding upland areas, in turn driving higher invertebrate populations which supports higher numbers of insectivorous birds and bats. Aspen stands also provide important structural conditions important to invertebrates and vertebrates not found in surrounding vegetation, including snags with cavities and coarse downed wood.

Study Area

City of Rocks National Reserve is located in south central Idaho near the town of Almo. The reserve consists of 5708 hectares (14107 acres) and includes unique granite rock formations. These formations provide habitat for a diversity of plant and animal species and attract a large number of visitors, especially rock climbers, each year. CIRO was primarily founded as a National Reserve out of a local desire to regulate the large population of climbers that flocked to CIRO each year and to interpret the historical landscape, including the existence of a segment of the California Trail in the reserve. Some of the rock inscriptions made be passing emigrants still persist today. CIRO is unique as a National Reserve because the historic uses of the park, including hunting and cattle grazing, are still permitted.

CIRO is at the northern edge of the Great Basin and sustains a high diversity of plants and animals, including some species, such as the single leaf pinyon pine (*Pinus monophylla*), cliff chipmunk (*Tamias dorsalis*), and pinyon mouse (*Peromyscus truei*), that are not present elsewhere in Idaho. Human activity, mainly fire suppression and livestock grazing, has increased the density of pinyon-juniper woodlands as well as non-native invasive weeds in the reserve.

Elevations in the reserve range from 5,650 feet where Circle Creek meets the east boundary of the Reserve to 8,867 feet at Graham Peak, in the northern portion of the park. Thirty-year precipitation data from Malta, Idaho, located 27 miles from CIRO, shows that the mean annual precipitation is 11 inches. Most precipitation falls during the winter and spring and snowpack can be persistent during most of the winter. Temperature extremes are common and August daily fluctuations can exceed 100^{o}F and reach near-freezing temperatures.

Eight aspen stands were sampled during the study period and all were located in the northwestern portion of the reserve near Bath Rock and Elephant Rock (Figure 2). The stands were of different sizes, elevation, and soil moisture regimes. All were within cattle grazing allotments.

Methods

A two-stage sampling design was used to characterize structural conditions in each stand where stands are treated as the primary sampling units and to which inferences are made, and plots are treated as the secondary sampling units. Standard deviations were only calculated for the primary sampling unit, following an assumption that 8 aspen stands represent less than 5% of the total number of aspen stands in the reserve, eliminating the need for use of a finite population correction factor and a standard deviation of secondary sampling units. This may not actually be the case, however, and more complex computations may be required once the total number of aspen stands available for sampling can be determined (i.e. n vs. N). Analysis of results followed methods outlined in Elzinga et al. (2001). All estimates of stand means are made for the number of stems per plot, rather than scaling up to stems per hectare, since the assumption that plots were representative of entire hectares was untenable.

Stands were non-randomly selected for sampling in several different grazing allotments. We adapted methods recently proposed for use in Wyoming and presented at the 2002 Conference on Fire, Fuel Treatments and Restoration in Ft. Collins, Colorado to sample aspen stands using 78 m^2 (5 m radii, 1/127th hectare) circular plots along transects with 12 m plot intervals. Origin plots were placed non-randomly in the approximate center of the aspen stand. Random azimuths were drawn from a computer-generated random numbers table and plots were placed at 12 m intervals along each transect until the stand edge was reached, at which time a second random azimuth was selected. Stand size and impassable barriers such as cliffs required some non-random selection of azimuths as well. Each stand received two azimuths and the number of plots per stand ranged from 5 to 10, depending on stand size and shape.

Garmin Etrex handheld GPS units with 5 m maximum accuracy were used to collect universal transverse mercator (UTM) coordinates of each plot center. UTM coordinates were collected in the 1983 North American Datum (NAD83).

Measurements in each plot included a stem count of all aspen and non-aspen trees and assignment of each stem into predetermined height classes. Classes included <2 m, 2-5 m, 5-10 m, and >10 m. Aspen snags were also counted. Visual estimates were used to assign stems to height classes. Additional information included plot elevation and comments regarding relative soil moisture conditions, density of under growth, presence of downed wood, and level of livestock presence.

Results

Figure 2 shows the location of stands and plots in the Bath Rock vicinity. Table 1 includes the location information for each stand. Table 2 shows the mean number of stems per 78 m^2 plot for each stand (n ranged from 5-10 plots/stand). An additional measure, sucker ratio, was also calculated from the proportion of sucker stems <2 m to total aspen stems, in order to capture the reproductive vigor of stands. The intermediate height classes were pooled as were all of the non-aspen tree species. Figure 3 shows the distribution of stems across all size classes. Table 3 shows the overall means, standard deviations, and 95% confidence intervals for stems per class and sucker ratio estimates from all 8 aspen stands.

All aspen stands were dominated by small aspen size classes. Stems <2 m accounted for over 50% of total aspen except in stand 3. The overall mean sucker ratio was 0.65. The mean number of aspen greater than 10 m per 78 m^2 plot was only 1.1 and only stand 7 had a significant number of trees greater than 10 m. Non-aspen trees present in stands included Utah juniper (*Juniperus osteosperma*), limber pine (*Pinus flexilis*), blue elderberry (*Sambucus cerulea*), chokecherry (*Prunus virginiana*), and willows (*Salix spp.*). Most non-aspen trees were less than 5 m tall, although stands 2 and 5 had several plots with tall juniper trees present that were overtopping the aspen canopy. Stand 3 had a large number of small chokecherry stems, which exceeded 30 in one plot. Aspen snags were present in all stands, and stand means ranged from 1.4 snags per plot to 6.7 snags per plot, with an overall mean of 3.5 snags per plot. Fallen aspen logs were also numerous in some plots.

The precision of estimates was relatively high for most stand measures and standard deviations were approximately 50% of their means except for the estimates of aspen stems >10 m and non-aspen stems. Due to the relatively low numbers of stems encountered in these classes, their standard deviations exceeded 100% of the means. Figures 4-6 show the results of simulated sequential sampling conducted in order to illustrate the effect of increasing sample size on the precision of means and standard deviations. Simulations were built off of the existing data, with the first 8 samples taken from the actual observed field data, and the remainder from randomly generated stand means. Random stand means were generated in Microsoft Excel using the random generator function and were selected from the observed range of extreme values in the first 8 samples. The validity of this simulation rests on the assumption that the observed ranges actually capture the population variability, which may not be true. Additional field data will be required in order to test this assumption. The running means and standard deviations stabilize at approximately 9-13 samples (stands) for means per plot of aspen stems < 2 m and sucker ratios, and the standard deviations are considerably less than 50% of the means. Running means and standard deviations for aspen stems > 10 m do not stabilize until approximately 20 samples and the standard deviation remains greater than 50%. Sample size requirements were calculated for estimating means per plot for aspens stems < 2 m, total aspen stems, and sucker ratios with 95% and 90% confidence intervals and with desired precision levels of $\pm$ 20% for aspen stems ($\pm$5 and $\pm$7 stems, respectively) and $\pm$10% for the sucker ratio ($\pm$ 6.5%). The results of these calculations are presented in table 4. An additional calculation was made to estimate the required sample size for detecting differences between two means from paired permanent sampling units (i.e. repeat sampling of permanent stands). Assuming a 75% correlation between paired stands from year to year (which requires validation), 16 stands will be required to detect a 10% difference in sucker ratios between years with 90% confidence and 90% power and 27 stands are required to detect a 20% difference in aspen stems < 2 m at the same level of confidence and power.

Discussion

All 8 stands sampled during this project were dominated by young suckering stems, suggesting that regeneration is not being suppressed at this time by fire suppression, grazing, competition or other possible causes. The relative absence of “over-topping” by non-aspen tree species is also significant and is apparently less of an immediate concern in CIRO than in other areas of the intermountain west. Both juniper and chokecherry have the potential to suppress regeneration, as a number of stands had numerous individuals of these species present. The relatively large number of snags and downed aspen logs are significant, both for their wildlife habitat value as well as their indication of historic stand structure. Disturbance events such as fires often lead to recruitment of new cohorts of suckers and snags, creating distinct even-aged structural classes and cohort “pulses”. This type of dynamic, if present in CIRO, will have implications on long-term monitoring design. Current stand conditions are dominated by young trees and the small number of stems in large height classes makes parameter estimation inefficient and sample size requirements excessive. Using a ratio, such as the sucker ratio in this project, may lead to more stable estimates over time. Based on the current set of pilot data, it is likely that a random sample of 25-30 aspen stands will provide adequate power to detect a 20% or greater change in certain stand characteristics (i.e. stems <2 m, total aspen stems, and sucker ratio). However, the scope of inference from these data is limited and cautious interpretation is advised until additional stands in other regions of the park are also sampled. A second year of data may be helpful for estimates of sample size requirements to detect change. One of the key assumptions in this determination is the year-to-year correlation between paired stands. However, the rate of change for long-lived tree species is slow enough that 75% correlation is a reasonable estimate and correlations are likely higher, making the current sample size estimates somewhat conservative. Measurement errors remain unaddressed here but also likely affect precision of estimates. Feedback from field assistants included concerns over plot boundary establishment and boundary decisions (i.e. “in” vs. “out” stems). Refinements in plot and transect selection may also be helpful, as will a randomization of sampled stands. The recently completed City of Rocks vegetation map will be very helpful in delineating the target population of aspens stands within the reserve boundary from which samples can be drawn. This will also allow a calculation of the percent of the targeted population actually sampled. If the percent exceeds 5%, the inclusion of the finite population factor will be required in analysis (and actually reduce sample size), but will require more complex equations associated with two-stage sampling of finite populations (Elzinga et al. 2001).

Acknowledgements

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Literature Cited

Elzinga, C.L., D.W. Salzer, J.W. Willoughby, and J.P. Gibbs. 2001. Monitoring plant and animal populations. Blackwell Science, London, England.

Griffis-Kyle, K.L. and P. Beier. 2003. Small isolated aspen stands enrich bird communities in southwestern ponderosa pine forests. Biological Conservation 110:375-385.

Larson, E. J. and W. J. Ripple. 2003. Aspen age structure in the northern Yellowstone ecosystem: USA. Forest Ecology and Management **179**: 469-482.

Lawler, J.J. and T.C. Edwards. 2002. Composition of cavity-nesting bird communities in montane aspen woodland fragments: the role of landscape context and forest structure. Condor 140:890-896.

Madison, E., K. Oelrich, T. Rodhouse, and L. Garrett. 2003. Mammal Inventories, City of Rocks National Reserve. University of Odaho, Moscow, Idaho. 43 pp.

Parsons, S., K.J. Lewis, and J.M. Psyllakis. 2003. Relationships between roosting habitat of bats and decay of aspen in the sub-boreal forests of British Columbia. Forest Ecology and Management 177:559-570.

Peet, R. K. 2000. Forests and meadows of the Rocky Mountains. Pages 75-121 *in* Barbour, M. G. and W. D. Billings, editors. North American terrestrial vegetation, second edition. Cambridge University Press, Cambridge, United Kingdom.

Rogers, P. 2002. Using forest health monitoring to assess aspen forest cover change in the southern Rockies ecoregion. Forest Ecology and Management 155:223-236.

Shive, J. and C. Peterson. 2001. Herpetological Inventory of the City of Rocks National Reserve. Idaho State University, Pocatello, Idaho 64 pp.

Tables and Figures

Table 1. The location, elevation, date, and observers of the 8 sampled aspen stands in City of Rocks National Reserve.

Stand	UTM X	UTM Y	Elevation	Data	Observers
1	274261	4660694	2000	6/26/2005	CIRO Staff
2	274225	4660623	2006	6/26/2005	CIRO/OMSI
3	273753	4661957	2224	6/27/2005	OMSI
4	273823	4662144	2198	6/27/2005	OMSI
5	274198	4662333	2076	6/27/2005	OMSI
6	274581	4662390	1992	6/27/2005	OMSI
7	274568	4660826	1993	6/28/2005	OMSI
8	274503	4660894	1999	6/28/2005	OMSI

Table 2. Estimated means for seven measures of aspen stand structural condition. Value units are the mean number of stems per 78 m2 plot. The sucker ratio is the mean proportion per plot of aspen stems < 2 m to total aspen stems.

Stand	Aspen <2m	Aspen 2-10m	Aspen >10m	Total Aspen	Aspen Snags	Non Aspen	Sucker Ratio
1	17.0	9.8	0.0	26.8	5.8	0.2	0.62
2	11.4	10.4	0.2	22.0	5.7	3.1	0.54
3	16.1	15.1	1.2	32.4	2.3	4.8	0.40
4	34.0	11.1	0.0	45.2	6.7	0.0	0.76
5	39.5	4.7	1.4	45.6	1.4	2.8	0.79
6	16.8	5.0	0.0	21.8	1.8	0.1	0.73
7	45.3	17.0	4.6	66.9	2.4	0.1	0.80
8	19.3	12.8	1.1	33.3	2.3	0.9	0.58

Table 3. The overall mean (per plot), standard deviation of the mean, and 95% confidence interval (upper and lower bounds) for each stand measure.

n=8	Aspen <2m	Aspen 2-10m	Aspen >10m	Total Aspen	Aspen Snags	Non Aspen	Sucker Ratio
Mean	24.9	10.7	1.0	36.7	3.5	1.4	0.65
Std. Dev.	12.7	4.3	1.5	15.2	2.1	1.8	0.14
95% CI Low	14.2	7.0	-0.2	23.9	1.8	0.0	0.53
95% CI Upp.	35.5	14.3	2.3	49.4	5.3	3.0	0.77

Table 4. Results from sample size requirement calculations for estimating single population means with specified levels of precision (20% and 10%). Results are shown for 95% and 90% confidence levels.

	$\bar{x} \pm$ 20%		$\bar{x} \pm$ 10%
	Aspen <2m	Total Aspen	Sucker Ratio
95% CI	37	25	27
90% CI	26	20	20

Figure 1. A conceptual model proposed by the Upper Columbia Basin Network to represent fire-driven aspen community dynamics in the City of Rocks National Reserve and Craters of the Moon National Monument. The dashed line represents a hypothesized or potential relationship.

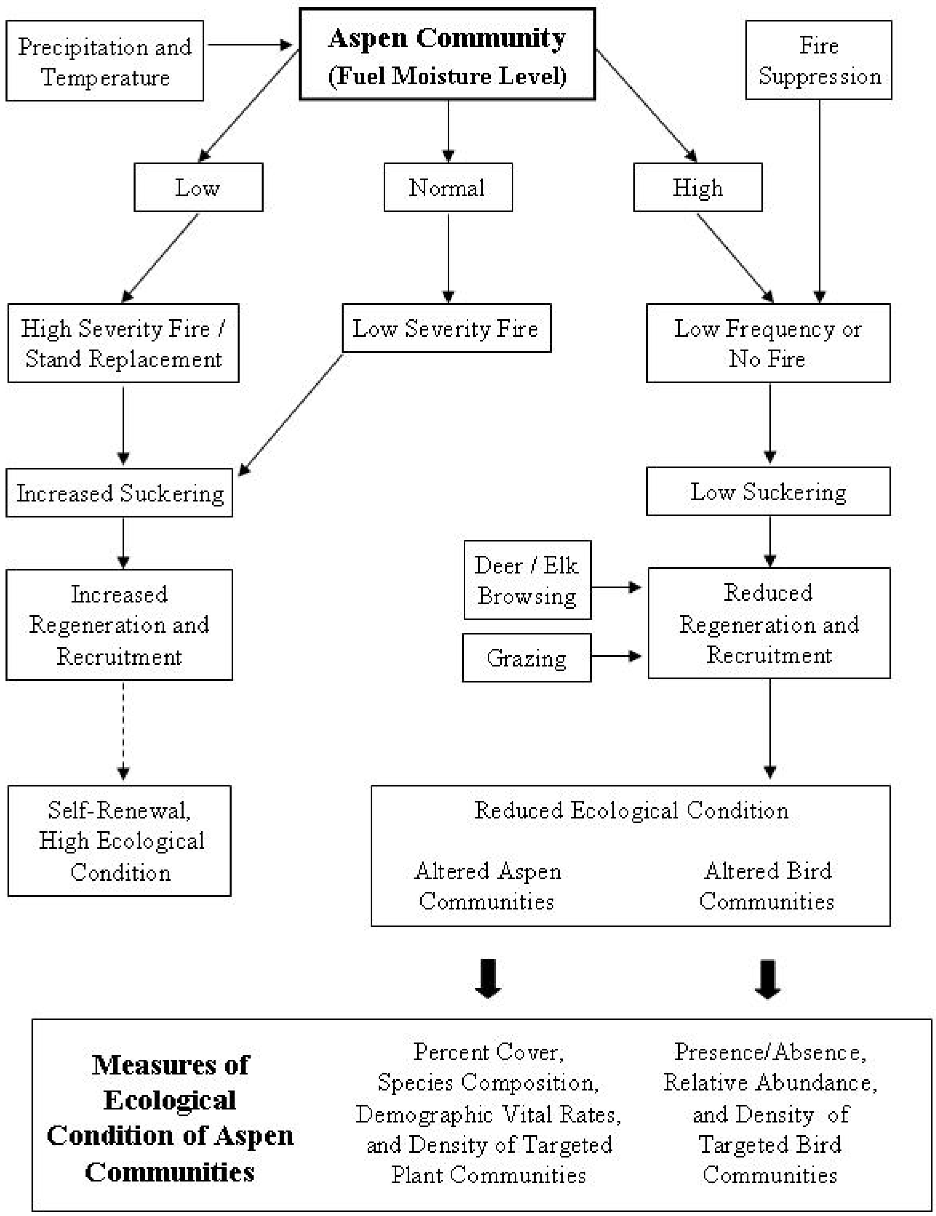

Figure 2. The stand and plot locations in the Bath Rock vicinity of City of Rocks National Reserve. Bath Rock is circled in red.

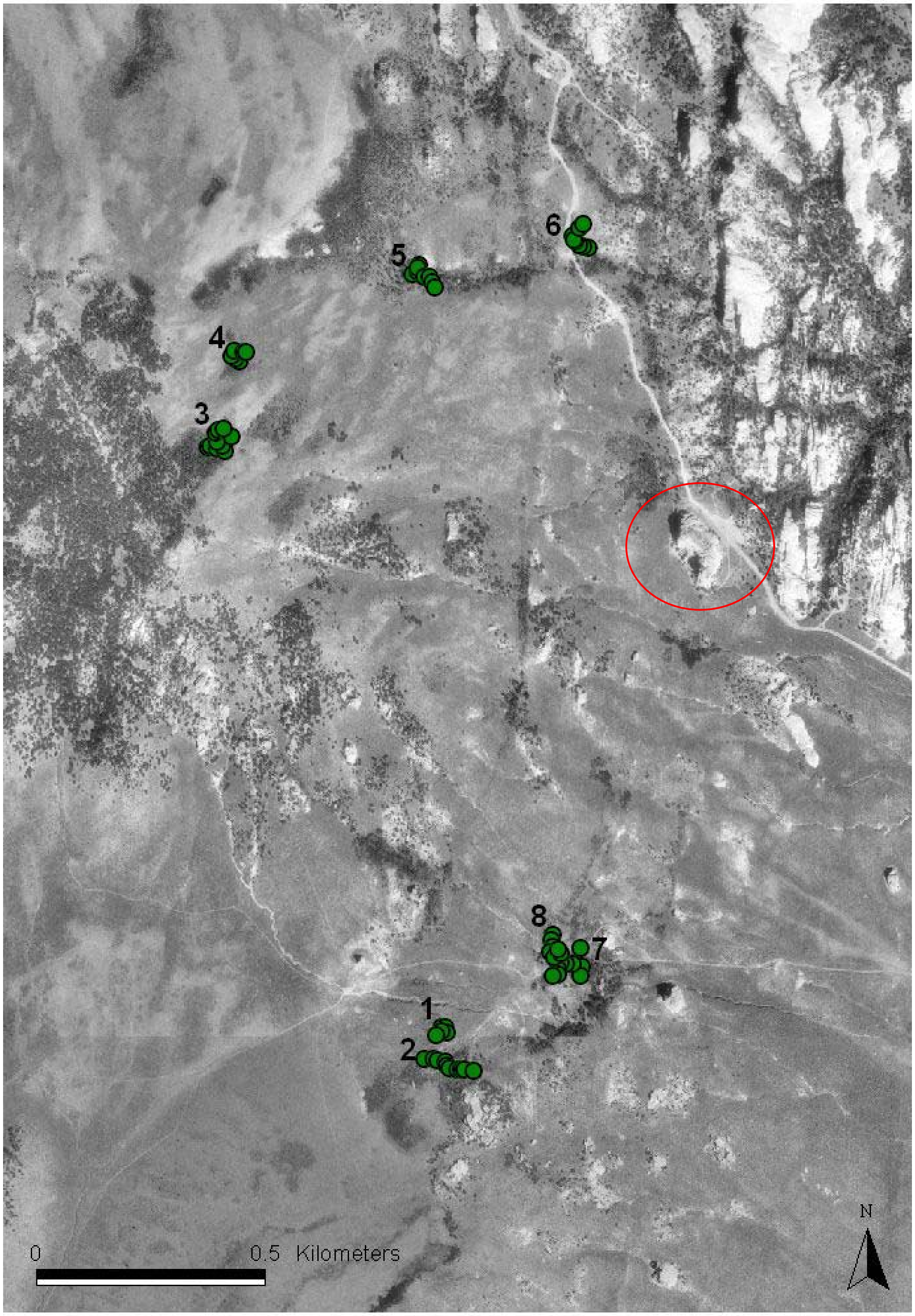

Figure 3. Distribution of aspen stem size classes and non-aspen trees in 8 sampled aspen stands.

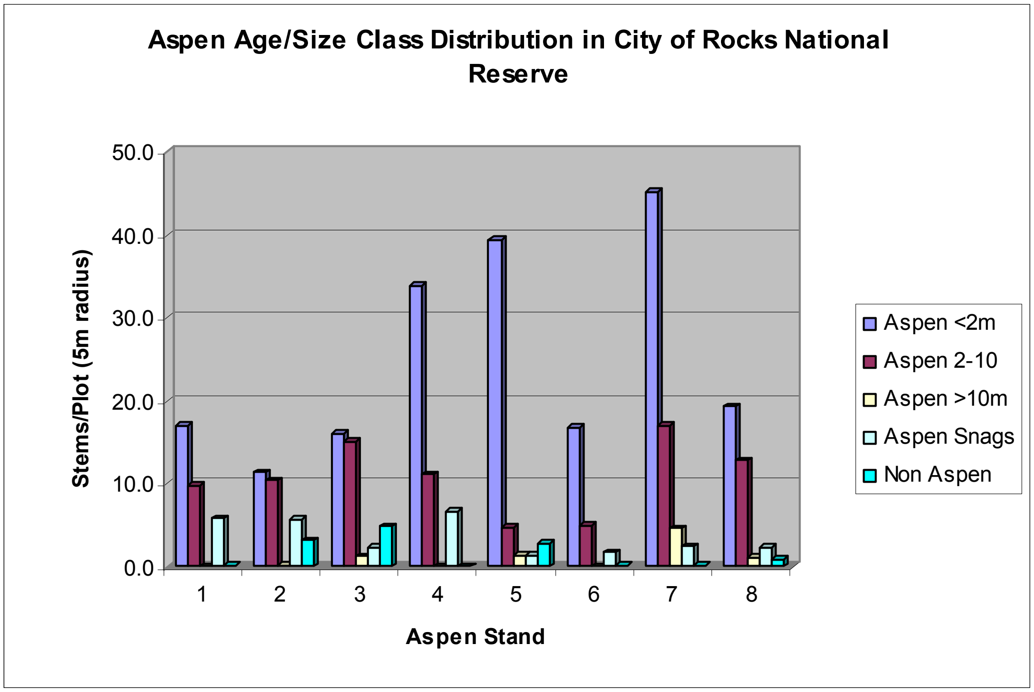

Figure 4. Simulated sequential sampling results. Running means and standard deviations computed with each additional sample size (stand) for mean aspen stems per plot < 2 m.

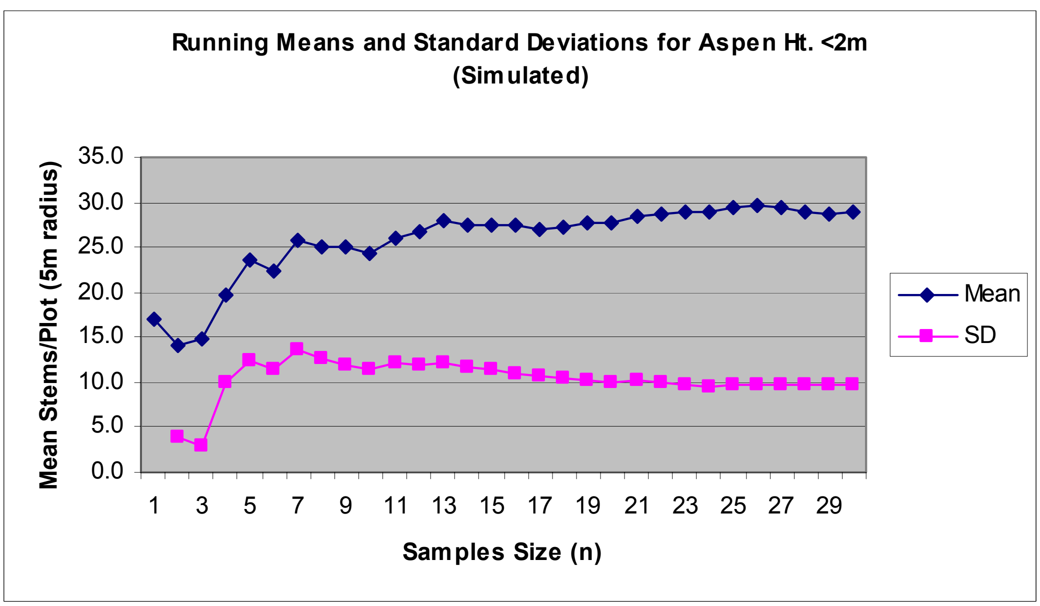

Figure 5. Simulated sequential sampling results. Running means and standard deviations computed with each additional sample size (stand) for mean aspen stems per plot > 10 m.

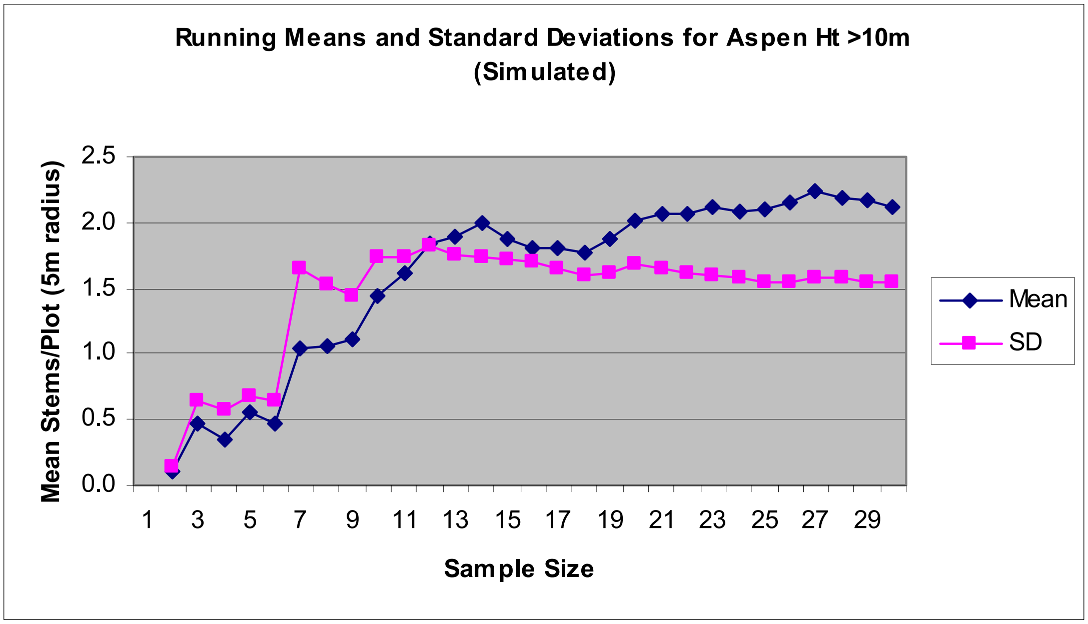

Figure 6. Simulated sequential sampling results. Running means and standard deviations computed with each additional sample size (stand) for mean aspen sucker ratios.